# Cardiovascular technology

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## COMPUTER TECHNOLOGY AND ITS APPLICATION TO CARDIOVASCULAR NURSING

Technology is the study of the practical arts and is sometimes called applied science. Technology is also the mechanism by which a society provides its members with those things needed or desired. It is clear that with heart and cardiovascular diseases being the No. 1 killers in the United States society has both the need and desire to minimize the catastrophic effects of these diseases. It is likely that there is no other field of medical endeavor more surrounded by computer technology than cardiovascular nursing. Cardiovascular nurses have thus become intimately involved with the use of computer technology in caring for their patients. The past two decades have seen extraordinary growth in the use of computer technology applicable to the care of the cardiovascular patient. These technologies apply to bedside monitors, imaging devices, defibrillators, pacemakers, Holter monitors, and telemetry systems. These devices have made what was "miraculous" just a few years ago seem "pedestrian" today.

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Central to these advancements is the digital computer. Reflecting on advancements in the computer field, a recent *Scientific American* article stated that "If the aircraft industry had evolved as spectacularly as the computer industry over the past 25 years, a Boeing 767 would cost $500 today, and it would circle the globe in 20 minutes on five gallons of fuel."[1]

To understand the impact digital computers are having in the care of the cardiovascular patient, consider the bedside physiologic monitor. The bedside monitor is the cornerstone of the modern ICU. All of the estimated 75,000 adult, pediatric, and neonatal intensive care beds operated in the United States are equipped with some type of bedside monitor. The simplest units display the ECG and heart rate and have rudimentary high-/low-rate alarms. The most sophisticated monitors can also analyze the ECG for cardiac arrhythmias, monitor intravascular pressures, assess respiratory status, calculate cardiac outputs from thermodilution curves, and continuously measure arterial and mixed venous oxygen saturation.

The use of microcomputers (like those used in personal computers) has revolutionized the acquisition, display, and processing of these physiologic signals. Today, the newest bedside monitors contain not one but a host of microcomputers. These bedside monitors have more computer power than earlier computer systems that filled large computer rooms and yet require less space than their predecessors' cooling fans.

Physiologic signals displayed by bedside monitors are now acquired with the aid of digital computers. The ECG signal is an example. After the appropriate leads are applied to the patient and the ECG is amplified, it is "digitized," a process that produces a string of numbers representing the amplitude of the ECG signal at very frequent intervals (usually more than 200 times per second). Once the ECG signal is digitized, it is then processed by a micro-

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computer. Bedside monitors with built-in microcomputers have many advantages over their analog predecessors:

- Systems can easily be improved and brought up-to-date by changing the "software" programs. The older analog systems required buying new hardware.
- The microcomputer-based bedside monitor can store long segments of patient waveform information (such as the ECG). As a result, sophisticated waveform pattern recognition required for arrhythmia monitoring is possible.
- Signal quality can be monitored and maintained. For example, the computer can "watch" for degradation of ECG skin/electrode contact resistance. If the contact is not adequate, the monitor can alert the nurse to the problem and indicate which electrode needs to be changed.
- Physiologic signals can be acquired more efficiently by "digitizing" them immediately after amplification. Thus calibration and signal filtering and processing can be simplified.
- Pattern recognition and waveform feature extraction can also be done in the microcomputer-based monitors. The computer can use waveform "templates" to identify abnormal waveform patterns such as classifying ECG arrhythmias.
- Selected waveform data can be easily stored for later review. For example, "strips" of interesting physiologic sequences, such as periods of arrhythmias or marked changes in heart rate, can now be stored. Also, derived variables such as heart rate and BP can be stored and later plotted as a trend to assist in the detection of time-oriented events that may be life threatening.
- Digital signal transmission from the bedside monitor is simpler and more reliable than with analog methods.
- Alarms from the bedside monitor are now much "smarter" and therefore less often false. In the past, alarm systems used only high-/low-threshold limits and were thus susceptible to signal artifacts. Now, with microcomputers in the bedside monitors, they can reliably distinguish between artifacts and disasters and can "confidently" alert nurses and physicians about problems.
- The bedside monitor can process many different physiologic signals and can use the information from one signal to verify another, for example, by comparing the heart rate derived from the ECG with that derived from the arterial pressure. Thus computer-based bedside monitoring systems are more like human observers who routinely cross-compare many types of redundant data.

How then does the microcomputer in the bedside monitor accomplish these important tasks? A computer is essentially a machine that receives, stores, manipulates, and communicates information. It does so by breaking down a task into logical operations that can be carried out on binary numbers—strings of 0s and 1s—executing them at a million operations per second. At the heart of the computer is the central processing unit (CPU), which carries out the basic arithmetic and logic functions and supervises the operation of the entire system. In bedside monitors the CPU is a microprocessor: a single integrated circuit on a silicon "chip" that has dimensions of less than a centimeter per side. To make the monitor operate, other silicon chips are used to give the computer its primary memory—the place where both instructions and data are stored. Still other chips oversee the input and output of data from the CPU and carry out control operations. Within the monitor these micro-chips are mounted on a heavy plastic circuit board; a printed pattern of conductors that interconnects the chips and supplies them with power.

Primary information is entered into the microcomputer-based bedside monitor by digitizing patient waveforms such as the ECG. Other information, such as which ECG lead selection and setting alarm limits, are entered into the computer via a keyboard of special function keys. The microcomputer-based bedside monitor's output is displayed on a screen. Since the signal displayed on the screen is in digital form, it can also be stored and printed out on a strip recorder or plotter.

The chips and screen of the microcomputer-based monitor constitute the bedside monitor's hardware. However, the hardware can do nothing by itself; to be functional it requires the array of programs, or instructions, collectively called "software." The core of the software is an "operating system" that controls the monitor's computer operations and manages the flow of information. The operating system mediates between the machine and the human operator and between the machine and the "applications" program to perform a specific task, such as finding the R wave in the ECG and calculating heart rate. In bedside monitors these applications programs are stored within the monitor itself while with personal computers these programs are stored on floppy disks.

The technology that has made the personal computer an invaluable tool for a wide variety of nursing, office, medical, and business applications has much to offer us in the care of our patients. We should all strive to learn and harness this unusually helpful tool to the betterment of patient care.

## REFERENCE

1. Toong H, Gupta A: Personal computers. *Scientific American* 1982;247(12):87.